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BIOLOGICAL BULLETIN.

THE HABITS OF CALIFORNIA TERMITES.

HAROLD HEATH.

Situation of Nest. — Of the six species of termites inhabiting the western part of the United States, three, *Termopsis angusticollis* Walk., *Calotermes castaneus* Burmeister, and *Termes lucifugus* Rossi, occur within one hundred miles of San Francisco. The first named is by far the largest and is seemingly the most abundant. At various points, for example the pine woods not far distant from the Hopkins Seaside Laboratory at Pacific Grove, colonies may be found in almost every stump and decaying log and even dead branches on otherwise healthy trees are frequently infested. As in the case of several other termites their excavations follow more or less closely the grain of the wood and are confined to its deeper portions, leaving an outer protective hull, perforated at various points by tunnels leading from the interior to extensive spaces beneath the bark where the eggs and young are housed during the warmer hours of the day. No galleries lead from the nest into the earth nor into adjacent regions as is the case with *Termes* and if for any reason a portion of a log containing the royal pair be separated even by a few inches from the remainder no intercommunication ever takes place and the latter in due time produces substitute royal forms which maintain the community.

Calotermes castaneus, scarcely more than half as long as the above-described species, appears to be comparatively rare in the central portions of the state. I have taken but two nests, one at Pacific Grove and another on the Stanford University campus, the first in a pine log also inhabited by *Termopsis* though the tunnels of the two did not communicate, the second in a eucalyptus stump. Judging from these two colonies their habits are

essentially the same as those of *Termopsis* though their movements are executed with greater deliberation.

Termes lucifugus, possibly introduced from Europe, has already been the subject of several papers, notably those of Lespes¹ and Grassi and Sandias,² and I have only a few observations to add. In California this species is almost as abundant as *Termopsis* and inhabits indifferently several species of oak, conifer and eucalyptus and is sometimes resident in orchard trees and vineyards. Occasionally it attacks the timbers of houses where the moisture is sufficient though its ravages are not serious. During the dry season from June to October, they frequently abandon their haunts above ground and, by means of subterranean tunnels, depart into more favorable regions. On several occasions I have seen them three or four feet beneath the surface and I am told that in some of the more arid sections of the state they sink their shafts to twice this depth. Under such circumstances the burrow does not follow roots as Grassi considers is the case with the European form, but plunges directly into the soil. This and other peculiarities connected with the burrowing habits of this species may be readily observed if a number of individuals are placed in a tall glass jar filled with earth and chips of wood. Almost immediately they commence to tunnel, removing bits of sand and earth to the surface or storing them in cracks with the rapidity of the true ants. Within a week the whole mass of soil is penetrated by a perfect labyrinth of tunnels, which in many places where the walls are in danger of falling in are lined with excrement. In old burrows the walls throughout possess this lining.

In addition to those galleries which pass downward into regions of sufficient moisture there are others that traverse the earth more or less parallel with its surface and sometimes, in the form of tunnels built of particles of wood, come above ground, where they are concealed under sticks and leaves. In one colony inhabiting a large root of the yellow lupine (*Lupinus arboreus*) in a patch of

¹ "Recherches sur l'organisation et les mœurs du Termite lucifuge," *Ann. Sci. Nat.* (4), V. (1856), pp. 227-282, pls. V.-VII.

² "Costituzione e Sviluppo della Società dei Termitidi," *Atti dell' Accademia glenica di Scienze Naturali in Catania*, Ser. 4, Vols. VI. and VII. (1893-4). Translation by W. F. Blandford in *Quart. Jour. Mic. Sci.*, Vols. XXXIX. and XL. (1897-8).

loamy soil in a rocky, mountainous district not far from San Jose at least a dozen such tubes existed. One of these, occasionally rising to the surface, led to another root nearly twenty feet away. Another extended in an opposite direction a little over thirteen feet, while some of the other tunnels traversed shorter distances. From these outlying posts other galleries extended and, so far as it was possible to judge, all the roots in that area, nearly an acre in extent, were inhabited by one extensive colony.

Number of Individuals in the Colony. — In such cases and even more where the areas are less circumscribed it becomes practically impossible to determine the limits of a community and the number of members composing it. From this colony just described I took 3,761 individuals — a number probably less than half. On another occasion I took over 1,800 winged forms as they were swarming from a hole almost in the middle of one of the much-travelled streets of Palo Alto. If it be true that the sexes of this species swarm at different times, as Grassi maintains, it becomes evident, in connection with the fact that the winged individuals compose considerably less than half of the colony, that the latter consists, in some cases at least, of over 6,000 inhabitants.

With *Termopsis* the number of individuals is less than in the above described cases. Where the colony is accompanied by the primary royal pair and has been in existence for from one to three and perhaps four or five years its members number from 50 to 1,000. After the death of the primary pair and several substitute royal forms have been developed the egg-laying process is relatively much more rapid and results in the formation of large communities. One such, inhabiting a huge pine log, numbered 3,221 and judging from the thousands of eggs deposited throughout the burrows this number must soon have been greatly exceeded. Under average conditions, however, 2,000 is probably about the usual number.

The nests of *Calotermes* were both small, in one case aggregating about 200 individuals, in the other nearly twice this number. These contained neither eggs nor young and were located in almost completely decayed wood and hence may not be perfectly typical.

Swarming and Founding of Colony. — As is well known, the usual termite colony consists of a royal pair, numerous soldiers,

workers (absent in *Calotermes*) and perfect insects together with larvæ in all stages of growth. The peculiarities of these castes in the California species will be discussed in connection with their breeding habits and the establishment of new colonies.

In the case of *Termopsis* the nymphs (larvæ of perfect insects with plainly visible wing buds) that have developed during the year, undergo their last molt in from ten to twenty minutes, sometimes in the late summer or early autumn, unfold their wings during the next two hours and within a fortnight have changed from relatively helpless individuals to the active, dark-hued insects ready for their extended nuptial flight. This takes place just at dusk and is preceded by a period of great restlessness. From openings which have been made for them by the workers they issue rapidly by twos and threes and, with scarcely any preliminary movements, rise into the air. Some soon fall to the ground but in an open country others may continue their flight fully a mile. At this time they are occasionally beset by numerous woodpeckers, bluejays, tohees, wrens and sparrows who, with much wrangling and chattering, banquet themselves far beyond their usual bedtime. When darkness has compelled them to desist bats continue the pursuit for another hour. So intent are these creatures upon the chase that it is not a difficult feat to strike them down, and in a woodpecker so secured twenty-six termites were found while a bat had captured thirty-three.

Despite these ravages a large number of insects escape and may be seen flying from one tree to another in search of a suitable spot for the establishment of a colony. Several times I have seen them dashing at door knobs and nail holes in houses and against discolored spots on trees and logs in search of a place where decay has begun. Succeeding in this they frequently shed their wings, though with some this act is accomplished almost at the moment of alighting, while with others it may be postponed until after their excavations have reached a considerable size. Curving the abdomen until it rests across the wings of one side they move backward and usually sidewise, thus bringing the tip of the wings against some construction and causing them to buckle and break off along the line of weakness at their base. The wings are never gnawed off.

It appears that in most cases a female selects the site for the

nest and during this process apparently pays very little attention to the one or more males that move about near her. On her falls most of the work of excavation, at least during the first few days, though occasionally when she comes to the outside after a prolonged period of work one of her companions may excavate for a time. In some cases one male appears to be more attentive than the others which often go off on short trips to investigate the cracks and crannies in the neighborhood and may ultimately disappear altogether. In other cases they are driven off by one male and again it sometimes happens that when the burrow becomes a sufficient size to accommodate two, a male takes up a position with the queen and prevents, by fierce lunges, the entry of another. In no case apparently does the female exercise a choice in this first stage of colonization.

Some males are seemingly of a milder disposition than usual, for occasionally one finds two of them in company with one female and, judging by the size of the colony, they have lived together in harmony for more than a year. At other times two females may be associated with one male; and in a few cases I have found two, three and even six pairs living in company. This happens more frequently in captivity, but in any case it apparently disturbs the reproductive process, for the number of accompanying offspring is unusually small. Where royal forms are introduced from other nests a fight almost invariably ensues, and is terminated only with the death of one of the contestants.

It has often been noticed that the antennæ of royal pairs are invariably mutilated. They are, however, intact during the nuptial flight and for three or four days after the entrance into their cell. On several occasions about this time I have seen one individual repeatedly pass one of its antennæ through its mandibles at intervals of perhaps half a minute. Each time it would apparently bite off a small portion and instantly start backward about half its length after the operation. It would then assume a stiff statuesque position with its head rotated to one side or walk with wobbling uncoördinated gait for a little distance before repeating the process. At other times one individual while cleaning the other would gnaw off the tip of the latter's antennæ upon which these same movements would result. The one so mutilated would soon perform the same operation upon the other and so

on in alternation, the final result being the reduction within a few hours of one, often both antennæ, to more or less of a stump-like condition. This operation does not prevent the royal pair from making their way about nor from finding their way back to their cell if removed from it for a distance of several inches. In fact the mutilation in no visible way affects their existence, and it is difficult to imagine of what service it is.

Upwards of a week later than this — that is almost a fortnight after swarming — I have on several occasions seen the royal pair of *Termopsis* in coitu. With their bodies closely appressed end to end in a straight line they remain from one to ten minutes in contact, after which they separate without any external indications that the process had taken place. Several times from a few days to many months later than this I have witnessed the same process in various colonies. With one pair kept in captivity this occurred at least a dozen times during eleven months and probably happened more frequently, though in a fairly high temperature (from 20–24° C.), such as is developed by placing them in close proximity to a lamp, this appears to be a much more frequent occurrence than in their normal cool moist habitat.

The swarming of *Calotermes* takes place in January and is quite similar to that of *Termopsis* as is the pairing process. Owing to the fact that I have had but one colony at a time new colonies were not established, but the males and females of the same community not only paired as though more distantly related, but mated and laid eggs. These were non-fertile, however, and soon grew white and disintegrated. *Calotermes* is rather difficult to keep in captivity, but some of these royal pairs lived for nearly five months and assumed almost exactly the size and appearance of the true royal progenitors of the original colony (Fig. 1) which were present in each of the two nests.

Termes lucifugus swarms at different times between the months of October and April. I have watched it more than a score of times and can confirm Grassi's observations in all essential particulars. It usually takes place about 11 A. M. and lasts nearly two hours. During its occurrence a few birds make their appearance and they, together with lizards (*Sceloporus*) and *Formica rufa*, reduce the size of the swarm somewhat though not seriously.

After their short flight the wings are almost immediately shed and the greater number of individuals pair, the male following immediately behind the female. According to Grassi (Blanford's translation, *t. c.*), "the one in front attempts to run away from the other, which pursues it and palpitates the extremity of its abdomen, and sometimes the sides as well. . . . I believe that the meaning of these supposed amorous displays is entirely different from that usually assigned to them, and that the pursuer wishes to solicit the dejecta from the one pursued."

FIG. 1.

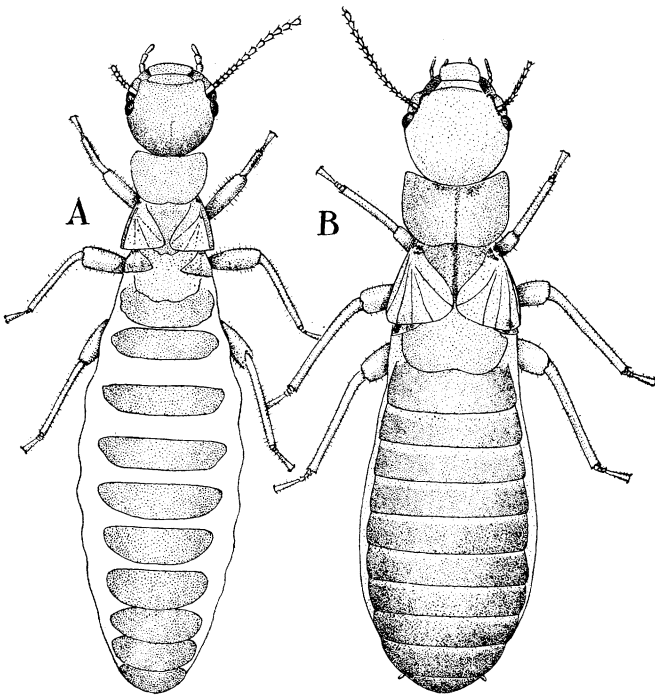


FIG. 1. Primary queens of (A) *Termes lucifugus*, eight months old, $\times 14$; (B) *Calotermes castaneus*, probably not less than four years old, $\times 9$.

This may be the correct explanation, but there are some facts that throw much doubt upon it. In the first place no food is taken by the perfect insect from the time of its last molt until the work of excavation has commenced and dissections show the alimentary canal to be almost empty. Secondly when one termite

solicits dejecta from another it scarcely ever pursues it for more than a centimeter unless there are signs that the scybalum is forthcoming, and even then the pursuit is only for a short distance. But here in the case of *Termes* one perfect insect often pursues the other for many meters, and I have noticed in the case of several which fell in some large cement basins that they kept it up for an entire afternoon and evening. Furthermore, if the individual behind becomes separated from the one in front the latter almost immediately stops and stands transfixed with the abdomen curved upward until it once more feels the palpitation of the antennæ of the one behind. The whole process suggests that some secretion located at the posterior extremity of the body attracts the one behind until the other finds a suitable spot for a nest.

Within a short time after mating the female burrows into the soil where this is soft ; otherwise she traverses some crevice and disappears from sight followed by the male. In Italy, according to Grassi, their subsequent careers are without result. Nevertheless, this investigator was able to obtain the commencement of a colony and Perris¹ notes that in the Landes royal pairs accompanied by eggs are of frequent occurrence under chips. In California this species is very difficult to keep, owing to its inability to withstand even slight changes in the amount of moisture in the nest. It thrives best in large jars filled with chips and earth, but even in this habitat it rarely lives over three or five months. Royal pairs, when placed in these surroundings, after swarming, disappear almost immediately and the following day may be seen next to the bottom of the jar a foot or so from the surface, excavating hollows in the wood and neighboring soil. Five weeks later I have found small clumps of eggs which in one colony hatched, but the young as well as the parents soon died.

Under natural conditions it is almost impossible to find these royal pairs, owing to their habit of burrowing in the soil, but I have secured four colonies after upwards of a year of watching. Three of these occupied excavations in some old fence posts almost completely buried in an unused gravel pit near San Jose. Placed in essentially the same conditions one and a half to two

¹ Ann. Soc. ent. France (5), VI., 1876, p. 201.

and a half feet beneath the surface they contained seven, nine and thirteen eggs and six, three and eight young respectively. The other colony was placed under and in a plank buried about a foot beneath the soil near Stanford University and contained the true royal pair, seven eggs, one soldier and twenty-seven workers and young of different sizes. From these few examples I am strongly of the opinion that the establishment of new colonies by means of true royal pairs is not only a normal process in California but very probably one of comparatively frequent occurrence.

As previously noted the true royal forms of all three species here considered, abstain from any form of nourishment from the time of their last molt until the process of excavation has begun, and no special supply of food is carried from the paternal roof in order to enable them to exist until the time arrives when they may be cared for by their offspring. On the other hand everything at this time is apparently sacrificed to lightness of body, resulting in a wider dispersal with less exhaustion than would result with forms loaded with fully developed reproductive organs or food either in or out of the body.

A very short time after excavation has commenced the abdomen of both male and female increases rapidly in size. That of the latter is slightly larger and more globular, but in both the enlargement is due to nutriment taken into the alimentary canal and to the developing reproductive elements. Within a month both have attained to nearly their maximum size which, as the figures show, is far short of that of some of the tropical forms. At no time do they require to be fed, and their size does not prevent their active locomotion from place to place.

Rate of Increase, etc. — As previously mentioned eggs are deposited in the newly made nests of *Termes lucifugus* within five weeks after pairing, but owing to the fact that these and the young are shifted about in galleries often away from the light, the observations I have made concerning the rate of egg-laying and the time required for hatching are very incomplete. This is also the case with *Calotermes*. *Termopsis*, on the other hand, is much more hardy and lends itself readily to observation and this, connected with their abundance, has placed me in possession of considerable data. They mate readily in captivity, and upwards of

500 true royal pairs now in my possession are in excellent condition after more than a year of captivity. They are also very abundant in recently killed trees, and it is an easy matter to use these colonies for checking up results. Stripping off the bark of such trees from three to nine months after the swarming period I have found scores, in fact hundreds, of small colonies accompanied by the royal pair.

Up to the present time no record has been made of the occurrence of a true royal pair within the United States. Messrs. Banks and Chittenden have kindly called my attention to a brief note by Hagen¹ to the effect that the late Mr. H. G. Hubbard found the queens of *Termes flavipes* in Florida. In this note Hagen remarks that the "females are undeveloped, being wingless, but sexually mature," which shows that they were substitute and not true royal forms. The royalty of such small species as *Termes* and *Calotermes* might easily escape detection, but as *Termopsis* is relatively huge and also abundant and widely distributed throughout the Pacific slope it is remarkable that they have not hitherto been discovered.

For *Termopsis* the date of egg-laying and the consequent development of a colony differs widely according to circumstances. When the habitat is unusually moist a royal pair may remain together for a year without producing offspring, and, on the other hand, under favorable conditions upwards of 75 young may be developed within this period of time. Usually a fortnight elapses from the time of pairing until the first egg is laid; and from one to six are deposited daily until the total number amounts from 15 to 30. Egg-laying now ceases and the parents give their time to enlarging the nest or to caring for the eggs which are objects of careful attention, being kept scrupulously clean and frequently shifted from place to place in the nest.

At the present time my observations are not sufficiently complete to justify an extended account of the rate of growth of the developing young, the number of molts they undergo and the origin of the various castes. With the primary royal pair these phenomena are continually subject to a gradual change. For example, early in the life of the colony a large-headed larva

¹ *American Naturalist*, Vol. 10, 1876, page 62.

arises as a result of what appears to be the third molt, and after three succeeding ecdyses it becomes a perfectly formed soldier. The latter, in long-established communities, is about 18 mm. in length and possesses 22 antennal segments, while the one first developed is but 10 mm. in length and has 18 or 19 segments. Upwards of three months later another immature soldier appears larger than the first and evidently formed as a result of more than three molts. More than three are also apparently required to give it the adult length of 12 mm. and usually 19 or 20 antennal segments. The new arrival, after the mandibles have become sufficiently chitinized, usually asserts its superiority by putting an end to the first. Other soldiers appear upon the scene from time to time, generally a little larger and occasionally with more antennal joints. Finally an equilibrium is established in this respect, but not until the colony has been established for a year at least.

The first workers also undergo their final molt at an early stage and, as with the soldier, those which appear later assume larger proportions until, finally, at the end of nearly two years, a limit is reached with some of the members which have attained a length of approximately 14 mm.

So far as I have seen nymphs do not occur until after the first year, in other words the first swarm of perfect insects leaves the nest at the end of the second year. They also are relatively small.

The life of all these first inhabitants is comparatively short. The king and queen early draft them into service, but when their place may be taken by other and more powerful individuals they disappear. In some cases they are undoubtedly dispatched, but it is by no means certain that this is always the case. After the colony is fully established soldiers and workers live at least two years and probably longer, though of this I cannot be positive. Regarding the king and queen it is certain that they live together for at least two years in the case of *Termopsis*. In three of the largest two-year-old colonies in my possession there are in the neighborhood of 200 individuals, while in some colonies headed by the royal pair I have found more than 1,000. From such nests many perfect insects have swarmed, and it is reasonable to

believe that they have existed for five years at least. There is not the slightest evidence that the kings do not live as long as the queens. After the death of the royal pair from natural or other causes the members of the orphaned colony (to use Grassi's expressive term) develop a number of substitute royal forms. The individuals chosen for this purpose are usually the larvæ of perfect insects in which the wing buds are barely visible. By some unknown process, possibly by a peculiar method of feeding or some change in their diet, the external larval characters are retained (the larvæ undergoing no subsequent molts), while the reproductive organs are stimulated to active growth culminating in full functional activity. Very shortly, often within a month after the death of the primary pair, these substitute forms may be detected, owing to their faint straw color, which rapidly grows to a very much darker tint during another month.

If only one of the royal pair be destroyed usually only one substitute form is developed, but when both perish from ten to forty substitutes appear, according to the size of the colony. In two nests carefully examined I found six substitute males and eleven females in one, and nine males and thirteen females in the other. As might be expected, these do not mate permanently, and one male may pair with three or four queens during the course of an hour.

The substitute individuals are fed and cleaned almost entirely by the workers, which also assume the care of the young. Accordingly the royal task consists almost altogether of egg-laying and is performed with comparative rapidity. Some of the larger queens (Fig. 2) lay continuously from seven to a dozen eggs in twenty-four hours and where several are associated together the colony rapidly assumes large proportions. In the extensive nest of *Termopsis* mentioned on page 48 there were over thirty substitute individuals which were congregated beneath a small strip of bark where the sun shone brightly, and with them was a clump of eggs, attended by many workers, that I carefully estimated at not less than 8,000.

In colonies where either the king or queen persists the substitute royal individual is invariably, so far as I know, an immature perfect insect, but where both have perished the substitute royalty

may sometimes contain a worker or a nymph or even a soldier capable of laying eggs. Such monstrous forms are not infrequent in large orphaned nests, but never apparently in colonies headed by the true royal pair. One may also find winged soldiers, soldiers with mandibles of varying size, and, as just mentioned, soldiers with wing buds, the straw-color characteristic of substitute forms and with functional reproductive organs. These

FIG. 2.

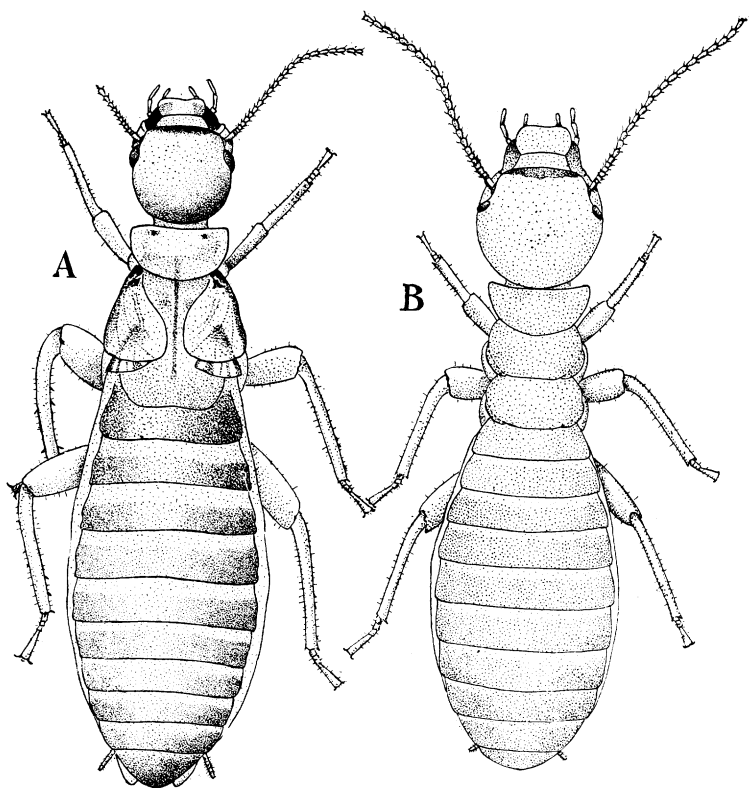


FIG. 2. A, primary queen of *Termopsis angusticollis*, at least four years old, $\times 6$; B, complementary queen of same species, $\times 7$.

last-named insects are comparatively rare. I have had but three in my possession. All of them laid eggs in captivity and in one case I followed the development for a long period of time, but the young and the nymphs and workers into which they became transformed, appeared in all respects perfectly normal.

Food, etc.—The food of termites consists almost wholly of wood gnawed directly from the wall of the burrow or solicited from some other individual. The primary royal pair appear to live almost altogether on food which they scrape off for themselves, When the young are hatched they are fed for some time on material regurgitated by the parents, but after a molt or two proctodeal food is added and finally constitutes almost the entire food supply procured from another individual.

After having fed a colony on oak or redwood (*Sequoia*) which produces dark-colored dejecta, and then changing the diet to white pine, it is easy to see that the greater part of the excrement, voided in the form of white pellets, never again enters the digestive tract of another individual. Apparently this is chiefly owing to its dryness. Some specimens, probably all at different times, appear to have the power of retaining a certain amount of moisture in the excreta. These are eagerly sought out by their companions which palpitate the abdomen of the one solicited with their antennæ and clasp its tip between their mandibles. If the stimulus be too early applied the one sought after runs away; otherwise it passes out the pellet which is greedily devoured. Occasionally one may feed itself in this way. This proctodeal food supply constitutes almost the sole diet of the substitute royalty, whose dejecta, like that of the soldiers, is never again devoured.

It appears to be a general belief that the soldiers, on account of the huge size of their mandibles, are able only with the greatest difficulty to solicit proctodeal food, and are accordingly in a chronic state of hunger. Sick or disabled individuals are greedily eaten by them, and at various times perfectly healthy forms are dispatched and devoured. Grassi supports this belief by some examples, but at the same time he notes that *Calotermes flavicollis* also solicits food in the usual way. With all the Californian species the soldiers are almost invariably at peace with their fellows. Moribund and possibly supernumerary forms are dispatched, but this is rarely done by the soldiers, who stand guard most of the time at some of the more exposed parts of the nest. At other times they move quietly among the workers and nymphs, and, with heads rotated to one side, solicit food with

very little difficulty. After watching many colonies for more than a year I have yet to see a soldier subsisting on any other kind of food. On one occasion I saw a soldier of *Calotermes* trying industriously to gnaw off part of the abdomen of a disabled nymph and at another time watched one biting a splinter of wood, but these efforts were of short duration and without success.

FIG. 3.

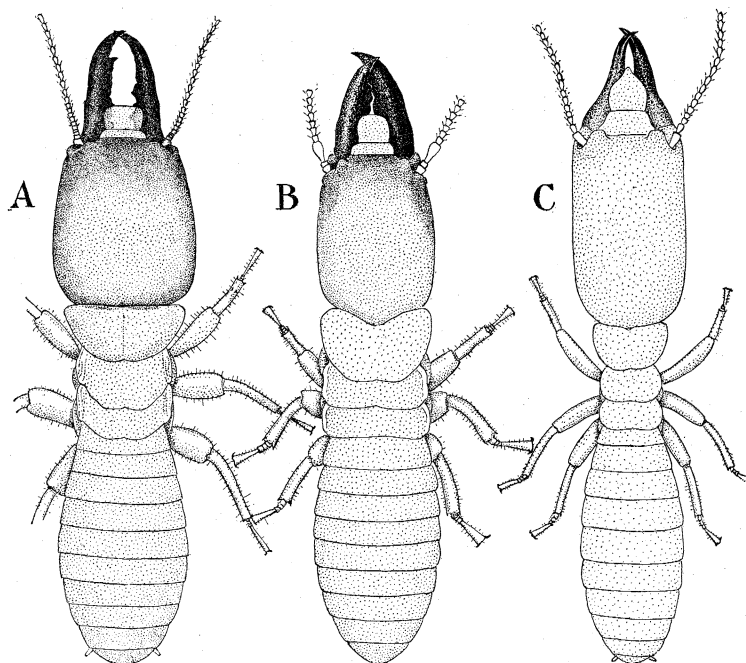


FIG. 3. Termite soldiers. A, *Termopsis angusticollis*, $\times 5$; B, *Calotermes castaneus*, $\times 9$; C, *Termes lucifugus*, $\times 12$.

On several occasions, while transferring colonies from their nests into jars, I have seen the soldiers of all three species rush frantically about and impale one of their fellows on their mandibles, but after quiet had been restored such acts were never repeated and it is safe to conclude that they form no part of the normal life of a colony.

In the presence of sufficient moisture the discarded rejectamenta are often used in the construction of barricades or for filling old beetle burrows; otherwise they are cast outside the nest.

Some species are said to cement the particles together by means of saliva or material regurgitated from the anterior part of the alimentary canal, while others employ the method of *Termopsis* and *Calotermes*. These, carrying a pellet in their mandibles, travel to some spot where building is required, and, feeling about with their antennæ, locate a breach in the wall. Facing about they then deposit a drop of liquid proctodeal material into which the excrement is quickly pressed with many waggings of the head, and immediately rush after another pellet which is likewise stuck fast. By this time the cement has set and the worker or nymph departs into the crowd, where it rests and is groomed by its fellows. In their natural surroundings the amount of building done by these insects is relatively small, but colonies kept in glass cases and in the presence of sufficient moisture, erect low but extensive roofs, elevated on many pillars, that serve to protect them from the light and other injurious agents.

It is now thoroughly well established that the soldier and worker in the termite colony are not the result of the arrested development of the reproductive organs. It has also been shown that they are not restricted to either sex. And it is almost equally certain that their differentiation is not to be traced back to the newly hatched young. The latter, when they first appear, are exactly alike in form and color, though they may exhibit slight differences in size, and the characteristics of the different castes develop at varying times after the first molt. If then neither arrested development, nor sex nor heredity are directly responsible for the production of soldiers and workers, what is the agent immediately concerned? Grassi is of the opinion that it is the food. Owing to its character or amount or both, the royal pair or the colony are able to transform the larvæ into soldiers, workers or perfect insects. Such a belief gains some support from allied phenomena among the social hymenoptera, but at the present time very little definite knowledge exists regarding this subject for the termites. For months I have fed a large number of termite colonies of all ages, with or without royal pairs, on various kinds and amounts of food—proctodeal food dissected from workers or in other cases from royal forms, stomodeal food from the same sources, sawdust to which different nutritious in-

gredients had been added—but in spite of all I cannot feel perfectly sure that I have influenced in any unusual way the growth of a single individual. However my experiments along this line are far from being completed and it appears best to hold the account of this phase of the subject for a future time.

STANFORD UNIVERSITY, CAL.,

October, 1902.